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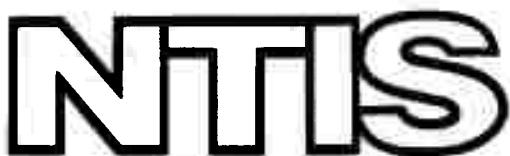
TEST INSTRUMENTATION SUBSYSTEM INTEGRA-
TION TEST PROGRAM REQUIREMENTS

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Boeing Company
Seattle, Washington

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THE BOEING COMPANY

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TITLE PAGE

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SECTION NO._____
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ACTIVE PAGE RECORD

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SYM	**DESCRIPTION**	**DATE**	**APPROVED**
A	The following changes were made in compliance to the X-20 System Program Office's request; Letter ASNRA-3/L. Price/slc/33190, dated August 30, 1963: Paragraph 3.2.1 The words "reproduced and" were deleted. Paragraph 4.3.2 The words "reproduced by" were deleted and the words "played back through" were inserted. AUTHORITY: BC-2-9500 MC	9/10/63	Et Ruffild Snow FOR L J Carr

REFERENCES

Government Documents

MIL E 6051 C   Electrical-Electronic System Compatibility
                and Interference Control Requirements for
                Aeronautical Weapon Systems, Associated
                Subsystems and Aircraft, dated 17 June 1960

Boeing Documents

D2-80600   Glider/Transition Detail Specification

D2-80102-5   Test Instrumentation Subsystem Integration Test
                Program Plan

D2-80102-2   Test Instrumentation Subsystem Integration Test
                Procedures (to be released)

D2-80103-3   Test Instrumentation Subsystem Integration Test
                Report (to be released)

ABBREVIATIONS

CTS   -   Communications and Tracking Subsystem

DSL   -   Data System Laboratory (Seattle)

FM   -   Frequency Modulation

IG   -   Inertial Guidance

PCM   -   Pulse Code Modulation

TICS   -   Test Instrumentation Checkout Set

TIC   -   Test Instrumentation Subsystem

CONTENTS

1.0   INTRODUCTION

1.1   This document presents the requirements for integration tests which
      are a part of the design qualification testing of the Test Instru-
      mentation Subsystem (TIS). The tests are termed, "integration tests,"
      since they will be performed as the individually qualified subcon-
      tractor and Boeing manufactured units are integrated in stages to
      the subsystem. These requirements will also apply to integration
      tests performed during acceptance tests of operational subsystems.

1.2   The tests will be performed in the Data Systems Laboratory where a
      Test Console will simulate the transducers and signal sources.

1.3   The measure of performance in the majority of tests will be data
      accuracy and acceptable performance will be based on the accuracies
      specified in the measurement list. Total subsystem accuracies will
      be determined by modifying the accuracies obtained in test in such
      a way as to include transducer and signal source accuracies.

1.4   A requirement exists for pre-emphasis schedules to be established
      for the transmission multiplexes as early as possible in the testing
      program to allow time for pre-emphasis resistor networks to be manu-
      factured for operational equipment. Tests, to determine these sche-
      dules, will be performed with the set of TIS equipment used for design
      qualification and requirements for these tests are included in this
      document.

1.5   Testing is divided into four sections and the requirements are defined
      for each of these sections. The division is such that it will be
      possible to determine the contribution to inaccuracy of each interface
      in the subsystem. The testing is divided as follows:

      (a) Airborne Conversion and Storage Equipment Integration Test,
           where the Test Console provides inputs to the Airborne Con-
           version Equipment.

      (b) Instrumentation Subsystem Integration Test, where the Signal
           Conditioning Equipment is integrated with the Airborne
           Conversion and Storage Equipment, and the Test Console
           simulates the glider interface.

      (c) Reference Test, where the TIS equipment is integrated with
           the TICS through the various test functions of the TICS.

      (d) Pre-emphasis test, where TIS equipment is combined with the
           Communications and Tracking Subsystem equipment to determine
           optimum pre-emphasis schedules.

      The sequence of testing will depend on the availability of equipment,
      and the schedule is given in D2-80102-5.

1.6   Other documentation relative to the TIS Integration effort is as
      follows: D2-80102-2, Procedure; D2-80102-3, Report; D2-80102-5, Plan.

2.0   TEST OBJECTIVES

2.1   Integration Tests

    (a)   To verify functional compatibility of the various data units of the TIS.

    (b)   To verify system procedures and equipment.

    (c)   To determine the necessary changes, if any, to the production equipment and test procedures to meet subsystem data accuracy requirements.

    (d)   Provide reference information for later subsystem tests involving the TICS.

2.2   Pre-Emphasis Test

    (a)   To determine the optimum pre-emphasis networks for the transmission data basebands.

    (b)   To determine the performance of the TIS equipment when the transmission data multiplexes are pre-emphasized as required for transmission through the Communication and Tracking Subsystem.

3.0 SUBSYSTEM CONFIGURATION

3.1 Equipment Configuration

3.1.1 Design qualification will be performed with one set of equipment in the O2 glider configuration. The units comprising the set will conform to the following drawings.

 (a) PCM Conversion Equipment Drawing No. 10-81003-2.

 (b) FM Conversion Equipment Drawing No. 10-81003-3. The particular VCO's to be employed, which correspond to the O2 glider configuration, are listed by channel number in Table 1 with the appropriate Electro-Mechanical Research, Inc. VCO drawing numbers included.

 (c) Airborne Tape Recorder Drawing No. 10-81003-5.

 (d) Mechanical Commutator Drawing No. 10-81003-8.

 (e) Signal Conditioning Equipment (the drawing number will be included when this equipment is defined).

 (f) TIS Ground Station 600045.

 (g) Test Instrumentation Checkout Set. (The drawing number will be included when this equipment is defined).

3.1.2 The airborne TIS units will be mounted in the Test Console which will supply power to these units in addition to simulating the transducers and signal sources of the O2 glider.

3.2 Test Configuration

3.2.1 Airborne Conversion and Storage Equipment Integration Test

The Test Console will provide inputs to the Airborne Conversion Equipment and the recorder output of the Airborne Conversion Equipment will be connected to the Airborne Tape Recorder. Tape recordings produced in the tests will be processed by the TIS Ground Station. The PCM data will be format converted by the ground station for computer evaluation.

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3.2.2 Instrumentation Subsystem Equipment Integration Test

The configuration will be as in 3.2.1 above, except that the Signal Conditioning Equipment will be connected. The Test Console will simulate transducers and signal sources for the Signal Conditioning Equipment.

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3.2.3   Reference Test

3.2.3.1   The Test Instrumentation Checkout Set (TICS) will simulate transducer
          or signal source variations for all channels where simulation capability
          is provided.

3.2.3.2   The reference test will be divided into three sections corresponding
          to the three test functions of the TICS. The test configurations will
          be as described in the following paragraphs.

3.2.3.3   Signal Conditioning Equipment - The Test Console will simulate the
          ambient condition of each transducer and signal source at the input to
          the Signal Conditioning Equipment. The TICS will be connected to the
          simulation connectors of the Signal Conditioning Equipment to simulate
          transducer and signal source variations and to the patch panel to
          measure the corresponding variation at the output of the Signal
          Conditioning Equipment.

3.2.3.4   Airborne Conversion and Storage Equipment - The TICS will be connected
          to the input of the Airborne Conversion Equipment, and the Airborne
          Tape Recorder will be set up to record the output for analysis by the
          TIS Ground Station and Computer.

3.2.3.5   TIS Simulation - The TIS will be set up with the Test Console connected
          to the input of the Signal Conditioning Equipment to simulate the
          ambient condition of each transducer and signal source. The TICS will
          be connected to the simulation connectors of the Signal Conditioning
          Equipment. The tape recorder will record the test data which will be
          evaluated by the TIS Ground Station and Computer.

3.2.4   Pre-Emphasis Test

          Pre-production Communication and Tracking Subsystem equipment will be
          used to represent a single communications channel. The Test Console
          will provide signal inputs to the Airborne Conversion Equipment, and
          the transmitter output of this unit will be connected to the trans-
          mitter. The VHF receiver output will be connected to the Ground
          Station.

4.0   TEST CONDITIONS

4.1   General

Integration Tests will be performed in a laboratory environment since the individual airborne units will have been fully tested with environmental variations during qualification testing.

4.2   Airborne Conversion and Storage Equipment Integration Test

4.2.1   The PCM data signal format of the Test Console will be fixed throughout the test, and the same format will be employed with each of the FM formats to be described in 4.2.2. The various PCM channel signals will represent the range of specified operating signal conditions, including over-voltage and common-mode conditions. There will be several levels representative of the normal data signal range to define the linearity of the PCM equipment.

4.2.2   The principle FM test will be an overall accuracy test where the accuracy is determined with as many characteristics contributing to the performance as possible. Other tests will check linearity and frequency response in such a manner as to isolate these effects. The conditions for the various tests are as follows.

4.2.2.1   Overall Accuracy - Each channel will be modulated in turn to full band-edge to band-edge deviation by a sinusoidal signal while all other channels are modulated with random noise. The frequency of the modulating signal will be one third the nominal modulation frequency of the particular channel. The random noise will be limited in frequency spectrum to the nominal maximum modulation frequency for each channel.

4.2.2.2   Linearity - For the channels with DC response, five DC signal levels will be applied over the nominal signal range. Sinusoidal signals will be applied to the channels with AC response only; five levels will be applied from small deviation to nominal maximum deviation. The signal frequency will be set to the constant amplitude portion of the modulation band of these channels.

4.2.2.3   Frequency Response - Both DC response and non-DC response channels will have sinusoidal signals applied at the nominal upper modulation frequency and the latter at the nominal lower modulation frequency also. A signal to determine a reference level will also be applied in the constant amplitude portion of the frequency band of each FM channel.

4.2.3   The accuracy of the IG channel will be determined with a simulated IG signal while all other FM channels are modulated with random noise as in 4.2.2.

4.2.4   All data will be recorded by the Airborne Tape Recorder. The TIS
         ground station will reproduce the data multiplex, format convert the
         PCM and I.G. data, and provide oscillographic records of the FM
         data.

4.3   Instrumentation Subsystem Integration Test

4.3.1   All signal sources of the first ground-launch vehicle will be
         represented by the Test Console. The Test Console will simulate
         conditions for zero or ambient and 90% for all channels of the
         subsystem.

4.3.2   The Airborne Conversion Equipment Multiplex output will be recorded
         by the Airborne Tape Recorder as the signal levels for each channel
         are varied. This tape recording will be played back through the TIS   R
         ground station, which will also format convert the PCM data and
         provide oscillograph record of the FM data.

4.4   Reference Test

4.4.1   Signal Conditioning Equipment

         The TICS will apply a signal voltage or impedance to each channel
         to simulate conditions equivalent to 10% and 90% of full scale or
         60% and 90% where the channel is at 50% for ambient condition.

4.4.2   Airborne Conversion and Storage Equipment

         The TICS will apply voltages to all PCM channels corresponding to
         zero, 10%, and 90% of full scale. For FM channels with DC response,
         DC voltages corresponding to zero and ±40% of full scale will be
         applied and FM channels with AC response only will have zero voltage
         and an AC voltage corresponding to 80% of full scale applied.

4.4.3   TIS Reference Test

         The TICS will apply a signal voltage or impedance at the simulation
         input of each channel to simulate conditions equivalent to 10% and
         90% of full scale or 60% and 90% of full scale where the channel is
         at 50% for ambient conditions.

4.5   Pre-Emphasis Test

4.5.1   The Communications and Tracking Subsystem equipment will be arranged
         to operate at SHF received signal levels in the range of carrier FM
         threshold for the receiver system.

4.5.2   The PCM format will represent a typical data format with signals in the specified operating range of the equipment. FM channel modulation inputs will be random noise inputs to represent vibration and flutter data, except where a measurement of channel noise is made, in which case the input will be grounded. A voice signal will also be applied to the voice channel and simulated I.G. data applied to the I.G. channel.

4.5.3   The test will be performed for both narrow band and wide band transmission data multiplexes.

4.5.4   The multiplex output of the VHF receiver will be monitored by the ground station.

5.0   DATA REQUIREMENTS

5.1   Airborne Conversion and Storage Equipment Integration Test

5.1.1   PCM Data - The PCM data will be recorded for six minutes with each of the conditions specified for the FM channels for a total of three records. Each record will be analyzed to determine the number of points within two tolerance levels for each PCM channel and for all PCM channels combined. For all FM conditions it is required that 95.5% of the points be within 0.6% of full scale of the correct level and 99.9% of the points be within 1% of full scale of the correct level.

5.1.2   I.G. Data - The I.G. data will be analyzed to determine the bit error rate. The I.G. data will be recorded for a total period of 12 minutes comprised of not more than two continuous recordings. It is required that not more than one error bit exist for the 12 minutes of recorded data.

5.1.3   FM Data - The FM data will be recorded for a six-minute period for each of the conditions specified to indicate overall accuracy, linearity, and frequency response. The data recorded to determine overall accuracy will be used to make error records where the modulating signal of each channel is attenuated by a notch filter. The filter bandwidth shall be such that the amplitude frequency product is not reduced more than 25% and the amplitude of each channel output will be increased in proportion to the actual reduction to compensate for filter attenuation. The error records will be analyzed to determine the probability of exceeding tolerance levels which depend on the nominal deviation ratios of the channels as shown below.

Nominal Deviation Ratio	Allowable Error for 1% Probability	Allowable Error for 0.1% Probability
1	± 14.5%	± 18.5%
2	± 5.8%	± 7.4%
5	± 2.0%	± 2.6%

Data will include an analysis of the accuracy at the 1.0% and 0.1% probability levels. It is required that the accuracies be within those shown above when applied to the appropriate channels. Alternatively the requirement for the FM channel accuracy can be expressed in terms of the time that the tolerances are exceeded. In this case the requirement is that the tolerances are not exceeded for a time greater than that indicated by the probability value. For the six-minute data record the 1% probability means that the tolerances associated with this probability must not be exceeded for more than a total of 3.6 seconds and the 0.1% probability that the associated tolerances must not be exceeded for more than a total of 0.36 seconds. The data to indicate linearity and frequency response will be analyzed to determine the linearity and frequency response for each channel.

5.2   Instrumentation Subsystem Integration Test

5.2.1   PCM Data - At least one minute of data will be recorded for each
PCM channel at each of two levels, zero or ambient and 90% of full
scale. The channels will be switched from zero or ambient to 90%
of full scale in turn with at least a one second period between
switching channels. The sequence of switching levels will be recorded.

5.2.2   The PCM data will be analyzed to insure that the changes at the
output occurred in the correct sequence with reference to the order
in which the inputs were switched. An accuracy analysis for each
channel will be made to determine the number of points within the
measurement list accuracy modified for the transducer or signal
source accuracy by the following equation:

$$A_r = \sqrt{A_m^2 - A_t^2}$$

where A_r is the required accuracy, A_m is the measurement list accuracy,
and A_t is the transducer accuracy.

The values for transducer accuracies are given in Table 2. It is
required that 95.5% of the data points fall within the required
accuracy of each level for each of the channels.

5.2.3   FM Data - An analysis of the FM data for each channel will be made
to determine the value which is exceeded 4.5% of the time. It is
required that this value will be within the required value obtained
from the equation in paragraph 5.2.2. The data will be analyzed
separately for each signal level for each channel.

5.3   Reference Test

All data obtained in this test will be retained for use as a reference
in later tests involving the TICS. Data will be obtained for those
channels which will not be stimulated.

5.3.1   Signal Conditioning Equipment

The accuracy of each channel will be determined and compared with
TBC requirements for the Signal Conditioning Equipment.

5.3.2   Airborne Conversion and Storage Equipment

Data will be obtained which will include two minutes of data for
each of the test conditions, e.g. the PCM data will include two
minutes at each of the test levels of 0, 10, and 90% of full scale
for all channels. For PCM data, the data will be analyzed to determine
the number of points within two tolerance levels of each of the
test levels of 0, 10 and 90% of full scale. It is required that
95.5% of the points be within 0.6% of full scale of the required
value and that 99.5% of the points be within 1% of full scale of the

5.3.2   (Continued)

required value at each of the three test levels. FM data analysis and requirements are as in 5.1.3. The accuracy must be within the allowable error at each of the test levels.

5.3.3   DTS Simulation Test

5.3.3.1 At least one minute of data will be recorded for each PCM channel at each of two levels, 10% and 90% of full scale. These levels will be 60% and 90% if the channel is at 5% in ambient conditions. The channels will be set to the lower signal condition initially and will be switched to 90% of full scale in turn allowing at least one second between switching channels. The sequence will be recorded. An accuracy analysis of the PCM data will be made as described in 5.2.2 and for the FM data as in 5.2.3.

5.4   Pre-Emphasis Test

5.4.1   The principal data to be obtained from this test will be the resistor schedules from the variable matrix which will define the optimum pre-emphasis schedules. The PCM bit accuracy and FM channel RMS noise for a range of SHF received signal levels corresponding to the data threshold will be recorded for each transmission data bandwidth. Strip chart recordings will also be made of the FM channel noise to indicate peak noise level.

5.4.2   Data will be obtained concerning the output transmission multiplexes. The Conversion and Storage Equipment transmitter output corresponding to the optimum pre-emphasis schedules will be measured both in terms of RMS voltage and percentage probability of exceeding a given voltage for each of the transmission data bandwidths. Also, the frequency spectrum of each multiplex will be recorded photographically with the FM channels unmodulated.

TABLE 1

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TABLE 2

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